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Recharging conditions and ages of the underground water in the valley of Bekaa (Lebanon)

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Abstract

The recharging's water of the aquifers is old and recent, but regarding the chemical facies of the aquifers (carbonated formations), it is very difficult to estimate the real ages of these waters without the use of a correcting's model of the ages after an intervention of the carbonated matrix in the mineralization of waters and in consequence in the activity of the Carbon-14 of the water (dissolution of the carbonated matrix formation with $A^{14}C$ (Activity of the Carbon-14) = 0 %). In the Anti-Lebanon, the Cenomanian's waters are older than the Jurassic's waters; in consequence, the rate of renewal of the Jurassic's groundwater is greater than the Cenomanian one.

Key words: carbon 14; datation; recharging; Bekaa; Lebanon.

1. INTRODUCTION

The results of the Carbon-14 activity analyses ($A^{14}C$ %) marked values which are between 11.4 % and 98 %, these values give an information about the existence of a local difference between the water infiltration's flow during their infiltration through the non saturated area and between their stay period in the aquifers. There is not a link between the activity in Carbon-14 and the water flow's direction. The old waters and having weak Carbon-14 activity are at the recharging's areas and at the piezometric domes. This phenomenon is due to the complexity of the

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Lebanese hydrogeologic system (evolved karst) and to the geologic structure very chequered and fractured (faults' areas, folds and fractures).

2. THE CARBON-14 ACTIVITIES OF THE GROUNDWATER

At the Mount-Lebanon, the $A^{14}C$ % of the groundwater (wells) is between 13 and 85 for an average about 46 % (Figure 1). This activity decreases from the south compartment to the north one (Table 1) (wells: D1 in Kefraya for 85 %, C1 in Jdita for 63 %, C4 in Nabi eila for 22.3 % and A6 in Wadi el karm for 13 %). These values confirm the important geological role of the Nordic part of the fault of Yammouneh which plays a role as an impermeability area for the water's transfer and for its flow's direction, but it is not the case at the south compartment of this fault. In the mountainous' formation where the Jurassic, the Cenomanian and the Neogen go up to the surface, the 4 wells indicated in the precedent paragraph were taken (C1 and D1 : Jurassic, C4 : Cenomanian, C5 : Neogen). The activities in Carbon-14 of the Jurassic's waters have the greatest values, and after we have the values of the Cenomanian's waters. In fact and provisionally, at the Mount-Lebanon, the renewal rate of the Jurassic's waters is more great than the rate of the Cenomanian [1].

At the Anti-Lebanon, 8 wells were taken as samples, the activities in Carbon-14 are between 11 and 98 for an average about 55 %. Only, one well from the Jurassic's aquifer was taken as a sample at the south compartment of the mountainous formation where the Jurassic goes up to the surface (D10 at Haloua : $A^{14}C$ = 61.5 %), 6 wells were sampled in the Cenomanian in the centre and the north of Anti-Lebanon (C10 at El Khedr : 11 %, C8 at Nabi Chit : 71 %, A9 at Orsal : 34 %, B6 at Younin : 49.6 %, B5 at Younin : 81.7 % and D8 at Bakka : 98 %) for an average about 57 %.

At the valley of Bekaa, 5 wells were sampled, the activities of Carbon-14 are between 38 % (D4 at El Mansoura) and 83 % (C5 at Rayack) for an average about 71 %. In general, the waters of the Cenomanian have the weakest value in activity of Carbon-14 (pcm: percentage in carbon modern).

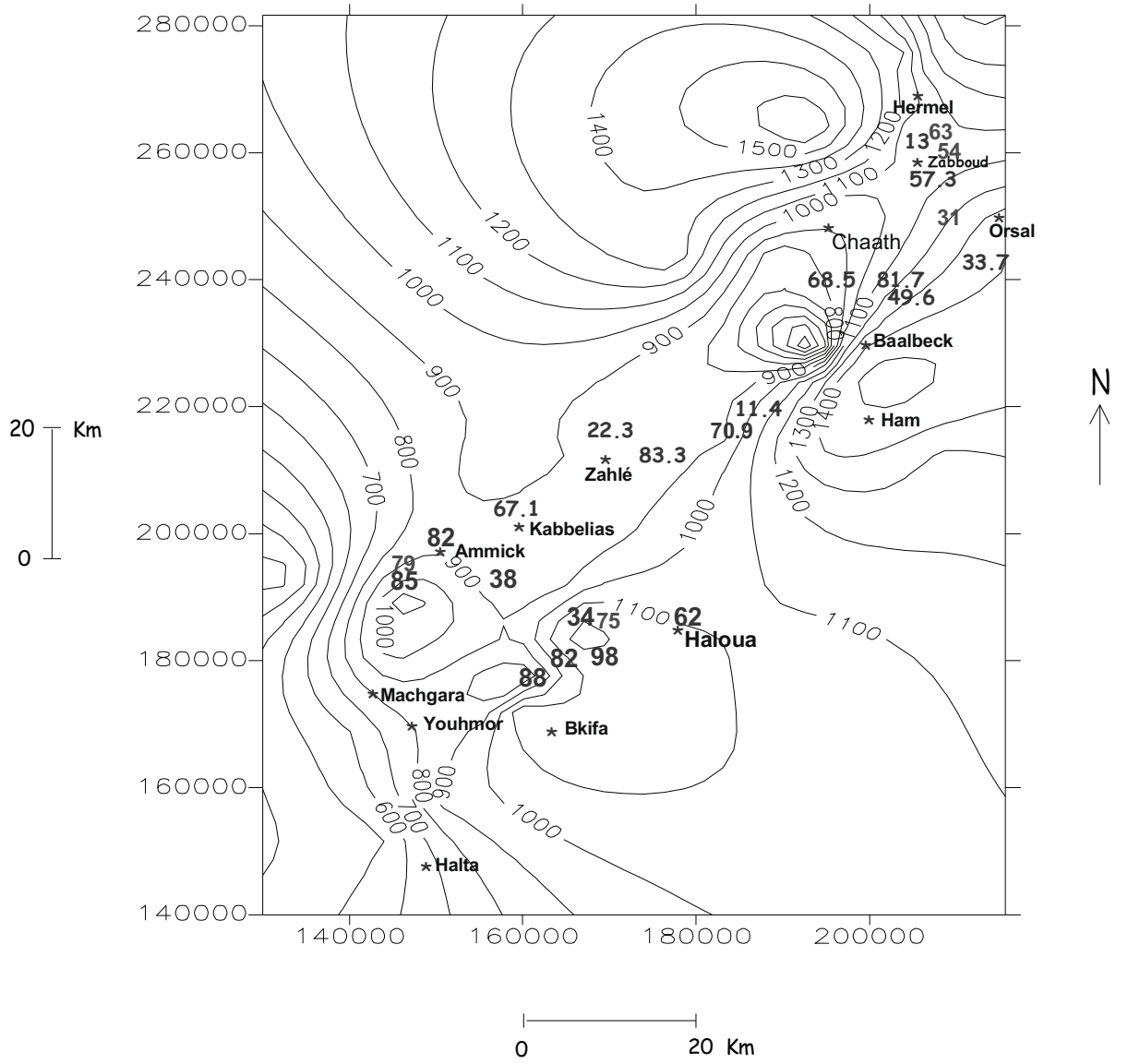

Figure 1: map of the distribution of the values in activity of Carbon-14 with the water table in the Bekaa.

Table 1: dating of the groundwater in the valley of Bekaa.

Site	Date	Reference	Nature	$A^{14}C$ % (pcm)	Age of the water (years BP) (BP = (Before Present)
Mount-Lebanon					
Jdita	05/04/2003	C1	Well	63	3961
Jdita	05/04/2003	S1	River	-	-
Kefrayia	17/04/2004	D1	Well	85	2317
Kefrayia	17/04/2004	Wadi el jaouz (S18)	Source	79	1269
Nabi eila	07/04/2003	C4	Well	22	11533
Nabi eila	07/04/2003	S2	Source	-	-
Niha	07/04/2003	S3	Niha source	-	-
Wadi el karm	10/04/2003	A6	Well	13	13264
Yammouneh	22/04/2003	S4	El Arbiin source	-	-
Yammouneh	22/04/2003	S5	El Moghr source	-	-
Bekaa					
Ammick	17/04/2004	D2	Well	82	2843
Ammick	17/04/2004	S19	Pond	-	-
El Mansoura	17/04/2004	D4	Well	38	6160
Hermel	09/04/2003	S6	Aîn el zarqa source	54	61
Hermel	10/04/2003	S7	Bdaîta source	-	-
Hermel	10/04/2003	S8	Ras el mal source	63	50
Hermel	10/04/2003	S9	El adim source	-	-
Laboueh	09/04/2003	S10	El Laboueh source	31	8833
Maqneh	12/04/2003	B3	Well	68	2123
Qasr- Hermel	27/04/2003	S11	Ebbish source	-	-
Rayack	05/04/2003	C5	Well	83	1386
Tal el akhdar	24/03/2004	S20	Pond	-	-
Zabboud	09/04/2003	A8	Well	57	4956
Anti-Lebanon					
Aîn Arab	18/04/2004	Aîn Baqa (S21)	Source	-	-
Aîn Arab	24/03/2004	S22	Pond	-	-
Aîta el Foukhar	19/04/2004	D9	Well	34	5146
Aîta el Foukhar	19/04/2004	Al Arich (S26)	Source	75	2011
Al Dakoui	17/04/2004	D7	Well	88	2444
Bakka	18/04/2004	D8	Well	98	1105
Bakka	18/04/2004	Aîn el Baîda (S24)	Source	-	-
Bakka	24/03/2004	S25	Pond	-	-
El khedr	05/04/2003	C10	Well	11	14243
Fakiha	16/04/2003	S12	Source	-	-
Haloua	19/04/2004	D10	Well	62	4523
Ham	08/04/2003	S13	El Khandaa source	-	-
Ham	08/04/2003	S14	Aîn el sghiré source	-	-
Mdoukha	19/04/2004	D6	Well	82	2658
Mdoukha	19/04/2004	El Chwaiti (S23)	Source	-	-
Nabi Chit	05/04/2003	C8	Well	71	2479
Orsal	09/04/2003	A9	Well	34	6892
Orsal	09/04/2003	S15	Aîn el choob source	-	-
Orsal	09/04/2003	S16	Riyan source	-	-
Younin	12/04/2003	B6	Well	50	5121
Younin	14/04/2003	B5	Well	82	2069
Yahfoufa	08/04/2003	S17	Source	-	-

3. ORIGIN OF THE MINERALIZATION

A logarithmic relation is between the $A^{14}C$ % and the $\delta^{13}C_{CITD}$ ‰ PDB (Figure 2), this relation give us an idea on the intervention of the matrix in the mineralization of the water by dissolution [2]. The biogenic Carbon coming from the respiration of the plants, from the degradation of the vegetation and from the oxidation of the organic matter, has an important role ($A^{14}C \approx 100$ %) in the mineralization. An intervention of the deeply juvenile CO_2 exists. The water of the Cenomanian has the weakest activities in Carbon-14 and the more enriched in $\delta^{13}C_{CITD}$, these waters are the oldest water; but this aquifer has strong activities in Carbon-14 for impoverished isotopic values in $\delta^{13}C_{CITD}$ (recent waters) (Figure 3).

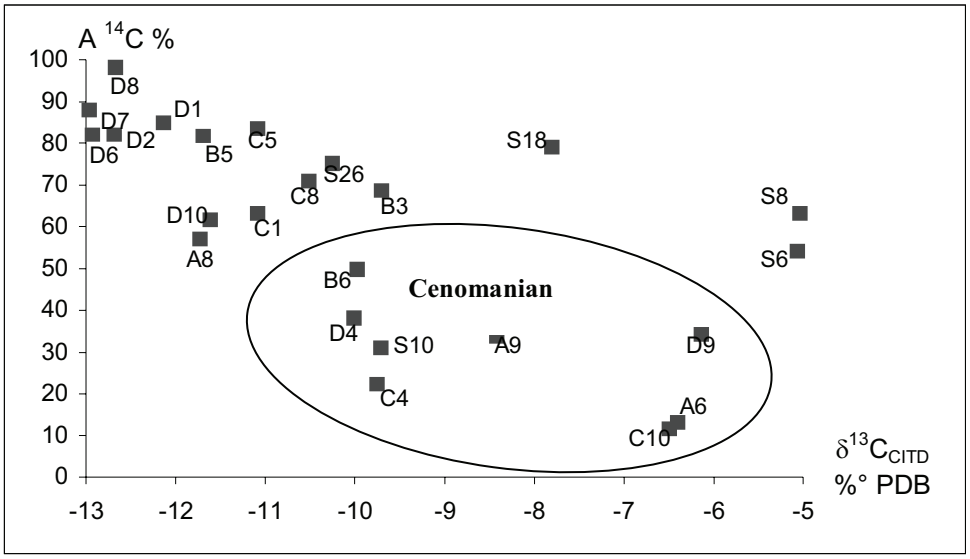

Figure 2 : the intervention of the carbonated matrix in the mineralization of the water.

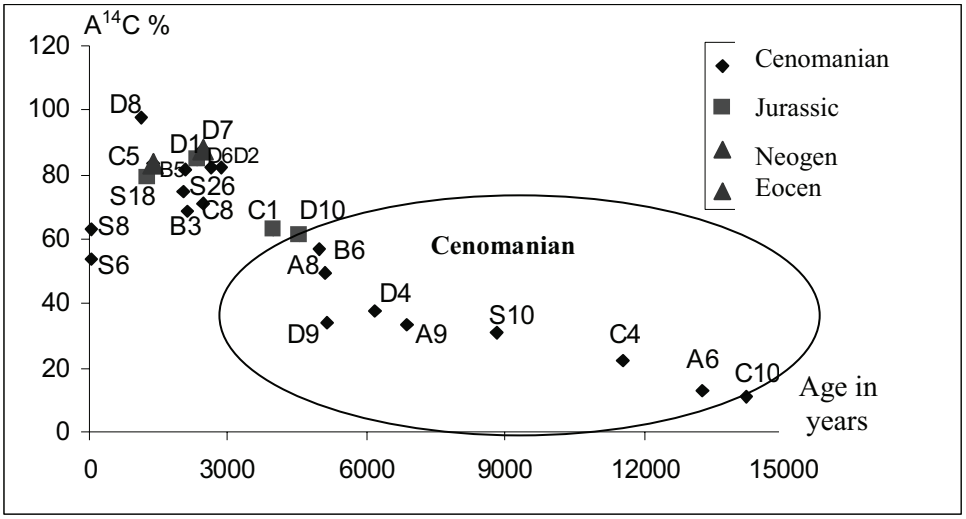

Figure 3 : activities in Carbon-14 and ages of the groundwater in the valley of Bekaa.

4. CONCLUSION

The dating of the water by Carbon-14 in the valley of Bekaa indicated ages which are between 50 (recent water with actual recharging) and 15000 years (old recharging's water). The Jurassic's water is relatively more old than the Eocen and the Neogen waters. The oldest waters are for the Cenomanian's aquifer and particularly along the faults at the two mountainous chains, the cenomanian's waters in the valley of Bekaa have strong values in $A^{14}C$ % (recent water) due to a mixing with the polluted superficial irrigation's water. An intervention for the juvenile Carbon is probable at the fault lines, this juvenile CO_2 goes up to the superficial areas as a gas [3]. In general a mixing between aquifers exists caused by rising and downward drainage.

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